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MEMORANDUM No. 4460

TITLE: **THE PROFILE DATA STRIP: A NEW APPROACH TO THE PRESENTATION OF FLIGHT PROGRESS DATA**

AUTHORS: **J O COOK & D A BASELEY**

DATE: **FEBRUARY 1991**

ABSTRACT

Advanced Air Traffic Control Systems are being designed to make full use of developments in Aircraft Flight Management Systems and Air-Ground Data Links. Current flight progress displays do not represent in any detail the actions or intentions of aircraft. This memorandum describes a method of using automation and modern graphic displays to make the presentation of flight progress data more dynamic and easily understood.

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THE PROFILE DATA STRIP: A NEW APPROACH TO THE PRESENTATION OF FLIGHT PROGRESS DATA.

1. Introduction

1.1 The method of recording the data on the progress of aircraft through the ATC system has been largely unchanged since the beginnings of organised ATC. This method, used today in the majority of ATC environments, involves the use of paper Flight Progress Strips, either hand-written or produced by computer from the aircrafts' Flight Plans, and updated by hand as the aircraft progress through the system.

1.2 There are considerable advantages attached to Flight Progress Strips: they form a permanent record, they are fast and easy to update; by using differently coloured pens, the person who has updated the strip is easily identified; and the simple physical act of writing on the strip and handling it has a "bonding" effect between controller and information.

1.3 On the debit side, only persons with direct visual access can use the information; data-transfer is not easy; and entries on the Flight Progress Strip do not update the data-base.

1.4 There have been many attempts to automate the Flight Progress Strip. In general, these attempts have taken the form of a data-line per aircraft on an E.D.D., with or without colour facilities. This approach has the advantage of updating the data-base and providing data-transfer functions. However, such displays can be difficult to read and interpret. (eg EDDUS) (Ref 1)

1.4.1 A recent experiment has been to replicate more or less exactly the Flight Progress Strip on a graphic display. In this case the controller is presented with the familiar strip layout, which would make the transition from pencil and paper to the electronic

strip much easier. Again, the data-base update and data-transfer facilities are included. (Ref 2)

1.5 The basic problem with both of these concepts is that they are still concerned with static information: they represent a means of recording what has happened and what control instructions have been given, rather than a guide to the future actions and intentions of the aircraft. It is now possible to remedy this defect by exploiting high-definition colour raster-scan displays and the power and speed of the modern computer.

2 The ATC Environment

2.1 A new method of displaying flight data is required for use in an advanced ATC system, which would utilise the vertical navigation capability of the aircraft as well as its track-keeping ability; and ground prediction of aircraft vertical profiles in addition to the current methods of ATC which rely primarily on the skills of the controller, using as his main tool the normal radar plan view display (PVD). (Ref 3)

2.2 The advanced ATC system would use, in addition to the PVD, a display showing a vertical slice of the airspace concerned. Using sophisticated algorithms to predict the spatial positions of aircraft, the picture could be "rolled forward" in time to enable the controller to view the expected positions of the traffic under his control at any instant in the future. (Fig 1). The controller could advance or retard the times of commencement of climbs and descents, or alter the cruising levels of aircraft, in order to minimise potential conflicts.

2.3 Experiments were conducted some years ago using a similar system under the title of Interactive Conflict Resolution (ICR). In this system, two controllers were involved: a Planner and an Executive. One area in which ICR was deficient was in the presentation to the Executive Controller of the plans made by the Planner. The Planner could resolve most potential conflict

situations by changes in assigned cruising levels or by changing the times of different vertical manoeuvres. This information was presented to the Executive in tabular form for him to act on. In fact, the Executive had great difficulty in interpreting the overall effect on the traffic situation of the instructions for which he was responsible: obviously an undesirable situation. (Ref 4)

2.4 This memo proposes a system of flight data presentation, which has the advantages of a certain amount of familiarity with the existing Flight Progress Strip (ie the dimensions, shape and colour), and also a novel concept for presenting the flight profiles for individual aircraft. The concept is readily understandable, and it attempts to break away from the static nature of the Flight Progress Strip. As it concerns chiefly the vertical profile of the aircraft, and to differentiate it from the Flight Progress Strip, the term has been coined "Profile Data Strips", (PDS)

3 The Profile Data Strip

3.1 The PDS is actually a pictorial representation on a high resolution colour graphic display of the aircraft's vertical flight profile for the whole of the flight sector under consideration. It can be marked with significant event times and potential conflicts. This vertical profile is produced directly from the aircraft's flight plan, which can then be modified by the controller if necessry to reduce the likelihood of conflicts. "Flight Plan", in this context, includes the initial request for an approved trajectory made from an aircraft fitted with full 4-D FMS and data-link.

3.2 **Aims of the Profile Data Strip**

The PDS will provide:

a. **Dynamic presentation of the actual and predicted positions of aircraft in the vertical and longitudinal planes.**

b. **A display of flight progress relative to the predictions.**

c. **An indication of the direction of flight.**

d. **An indication of possible conflicts.**

e. **Marking of significant event times and flight levels.**

f. **Marking of reporting points and sector boundaries.**

g. **Visual comparisons of positions of tops and bottoms of climbs and descents.**

3.3 Layout of the Profile Data Strip

3.3.1 This is shown in Fig.2. The dimensions of the PDS have not been finalised, but a strip slightly shorter and wider than the current paper flight progress strip (8" x 1") should suffice. The basic colours used for the PDS will conform to normal ATC practice, ie blue for westbound and buff for eastbound traffic, with pink used for non-standard traffic such as military aircraft which are in the system for only a short time. These colours would be light tints, not saturated, the object being to keep the whole display at a reasonable level of brightness. (For a detailed analysis of the use of colour for ATC displays, see Ref 5)

3.3.2 **A single strip is used to represent the whole of that portion of the airway under control of the relevant control sector: the solid vertical lines near each end of the strip indicate the limits of authority of the particular control sector. It can be seen that the strip extends slightly into adjacent control sectors: this is to ease handover problems. Reporting points and beacon positions are indicated by a dotted vertical line at the appropriate positions along the track of the airway. The vertical dimension of the strip represents ground level to FL450.**

3.3.3 The aircraft's vertical profile is marked by a black line, with a symbol to indicate the actual position of the aircraft at the time. A dotted (rather than solid) line indicates that the trajectory or part of it is only provisional. For example, the initial trajectory produced directly from the aircraft's flight plan would be shown as a dotted line. When the Planning Controller has confirmed the trajectory, including such modifications as may be necessary, and if required agreed it with the aircraft, the dotted line would become solid.

3.3.4 Times of entry into and exit from the sector are shown at the corresponding points on the strip. Marked against the aircraft's profile are the times at which the aircraft is expected to commence and to finish any vertical manoeuvre. Relevant flight levels are also marked. The aircraft's callsign and type appear in white in a "window" at bottom centre of the strip.

3.3.5 Note that a potential conflict is illustrated; the callsign, level and flight attitude of the conflicting aircraft, and the time at which the conflict will occur, are shown. The controller can consult his PVD at the relevant time to see whether avoiding action is warranted.

3.3.6 Route information within the UK airspace, and final destination, are tabulated at the entry end of the strip.

3.4 Construction of the Profile Data Strip

3.4.1 As stated in 3.1 the Profile Data Strip is constructed initially from the aircraft's Flight Plan. When the flight plan is passed from the bulk store to the data-base, it is passed through appropriate prediction algorithms. It is assumed that the aircraft will follow the Standard Instrument Departure (SID) for the route, following which it will climb to its requested cruising level at its normal climbing speed. It will remain at its cruising level until it leaves the Air Traffic Control Centre (ATCC) area of responsibility. If the aircraft is planned to

land or to descend within that area, then it is assumed that it will descend at a suitable time at its normal descent speed in order to achieve the correct level at the destination's holding facility or area exit point. Meteorological factors (ie wind and temperature) will be taken into account during the calculations.

3.4.2 The output of the foregoing process will be presented as the vertical profile of the flight on the Profile Data Strip, and will be displayed to the Planning Controller in the "pending" area of his display. At this stage, the whole of the strip will be coloured in the appropriate tint: buff for eastbound and pale blue for westbound aircraft. The times of significant events (ie start and finish of climb or descent, ETA's at reporting points etc) will be calculated from the aircraft's filed speeds, wind effects and the performance data; they will be marked on the strip.

3.4.3 When the aircraft is near to take-off, say within 5 minutes, the Planning Controller will examine the aircraft's proposed flight profile against the profiles of other aircraft on the route, using his Vertical Display, (see para 2.2). The Controller can modify the proposed profile by altering the times of climbs or descents, or assigning different cruising levels. He can also assign a parallel track if necessary: this could be indicated by a different colour for the profile on the strip. When the Planning Controller is satisfied, the Profile Data Strip is transferred to the "Imminent" area of his data-display, and also to an "Imminent" area of the data-display of the Tactical Controller.

3.4.4 When the aircraft is airborne, the take-off time is passed to Planning Controller and the Tactical Controller, who can then move the strip into appropriate positions on their "Active Data" displays. At this stage, the PC can carry out a final check, using his Vertical Display, on the validity of the aircraft's proposed trajectory to ensure that as many potential conflicts as

possible have been removed. Any modifications made must appear on the corresponding strips on the PC's and TC's displays.

3.4.5 At the time that the PDS is transferred to the TC's Active Data display, the times of significant events associated with the aircraft are entered in chronological order in an Event List on the display. Thus the Tactical Controller is aware of the times at which aircraft will climb (or be instructed to climb) etc. He can build up a mental picture of the traffic pattern in the vertical as well as the horizontal.

4 Dynamics of the Profile Data Strip

4.1 When airborne, the aircraft's position is determined either by radar/SSR-Mode C or from the aircraft's 4-D FMS System, passed via data-link. In addition to the display of position and height on the controller's plan view display, it is reproduced in the appropriate position on the Profile Data Strip, ie in the correct longitudinal position along track, and at the correct height.

4.2 The "airborne" message is also a signal for the start of the coloured background (blue or buff) to commence moving at the planned groundspeed of the aircraft. For eastbound aircraft the strip colour movement will be from left to right, and for westbounds, vice-versa: As time progresses, less and less of the strip colour remains.

4.3 Use of this technique means that the aircraft position relative to its prediction or plan is immediately apparent. If the aircraft symbol is in the coloured section of the strip, then it is early; if it is in the uncoloured portion it is late. Aircraft climbing or descending at a higher or lower rate than predicted will appear above or below the line of the vertical profile.

4.4 The aircraft vertical profile will be cancelled behind its current position on the strip.

4.5 The major task of the Planning Controller is to use his Vertical Display to plan aircraft clearances to be as free as possible from conflicts. However, there will be occasions when completely conflict-free paths are difficult to plan. Under these circumstances, any residual potential conflicts must be made known to the Tactical Controller. This can be done via the Profile Data Strip. The time and place of the conflict can be extracted from the Vertical Display and marked in red on the PDS, with the callsign of the conflicting aircraft, its altitude and flight attitude. The Tactical Controller can then observe the situation on his plan view display and decide what action to take.

4.6 If the approved flight profile is re-planned during the aircraft's flight, then it will of course be calculated from the present position of the aircraft. From the time of the new plan's approval, the strip-colour area will start at the current position of the aircraft, ie at that time, the aircraft will be neither early nor late.

4.7 Crossing conflicts (ie with aircraft whose flight path is at right angles to the track of the aircraft displayed on the strip) are represented on the strip by a block of contrasting colour covering the appropriate position and height band. This method can also be used to depict any area of airspace which is restricted in some way.

5 Advantages of the Profile Data Strip.

5.1
- a. The aircraft intentions are immediately apparent to the controller: the graphical format is easy to understand.
- b. Single-strip operation is possible.
- c. Updates of the plan are easily illustrated.
- d. The presentation is dynamic.
- e. It is immediately obvious that an aircraft is early or late, or climbing/descending either faster or slower than anticipated.

f. Possible conflicts are warned in good time to the Controller.

g. The standard strip colours can be maintained, easing the transition from old to new systems.

h. The system is well within the scope of today's technology.

i. The PDS concept can be used with or without aircraft fitted with 4D-FMS and Data-Links.

j. It provides a graphical indication of conflicts in the vertical plane with simultaneous along-track information.

6. Conclusions.

6.1 The concept of the Profile Data Strip could represent a major step foward in the presentation of flight progress data to air traffic controllers. It is an attempt to get away from the static, tabular display of information in favour of a more easily understood form.

6.2 Trajectory prediction plays a large part in the concept. Studies have shown that trajectories can be predicted to an acceptable degree of accuracy for at least 20 mins ahead (Ref 6): modern flight management and navigation systems will improve on this. There is still much work to be done on transfer of data from the Vertical Display to the Profile Data Strip, and the format and dimensions of both strip and data. But the concept is at least promising and deserves further study and development.

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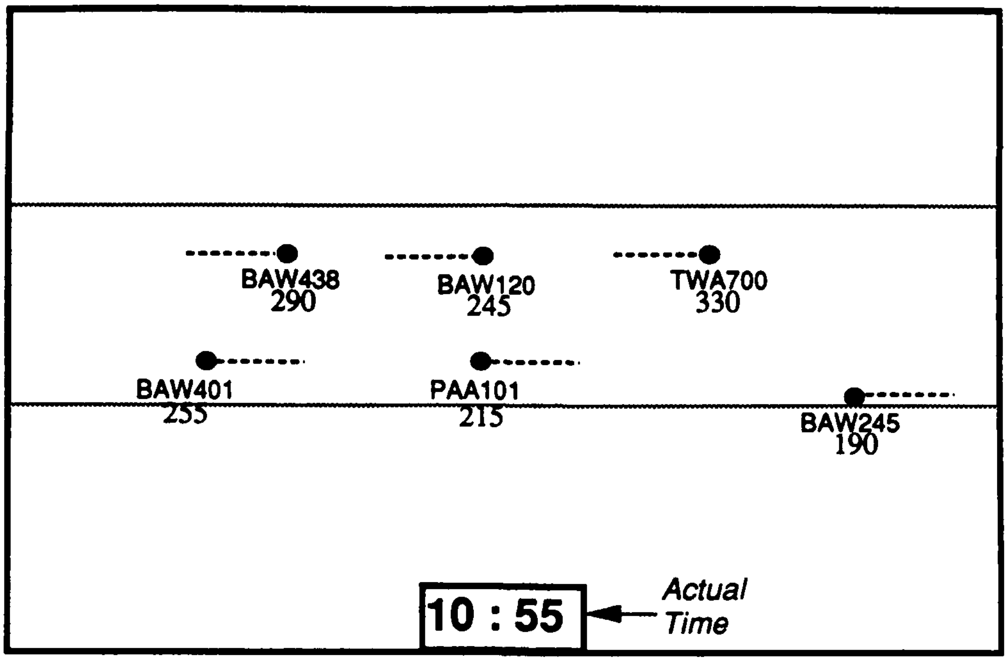
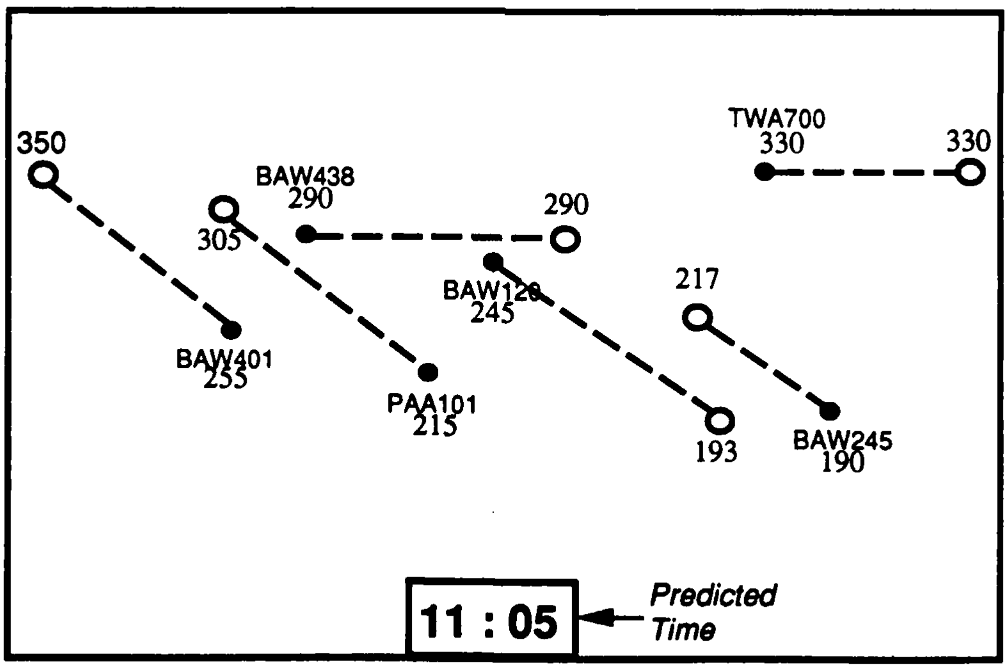


PLAN VIEW DISPLAY



VERTICAL DISPLAY

FIGURE 1

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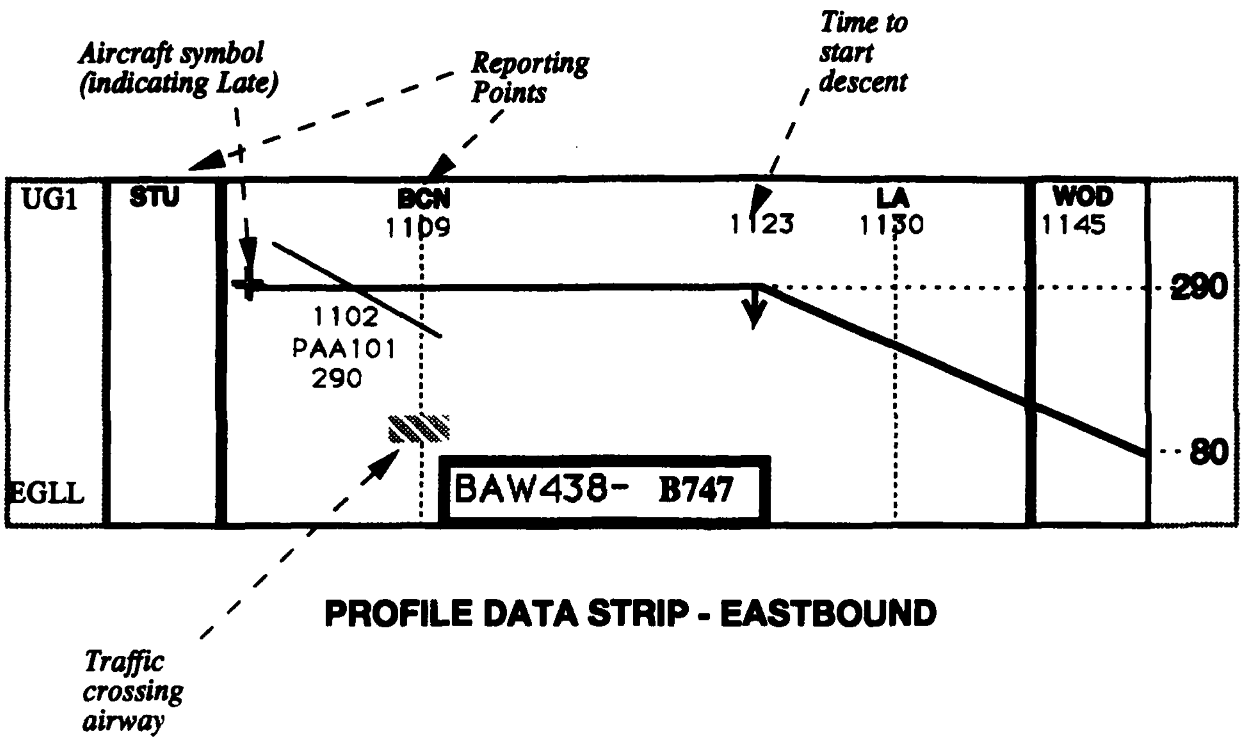
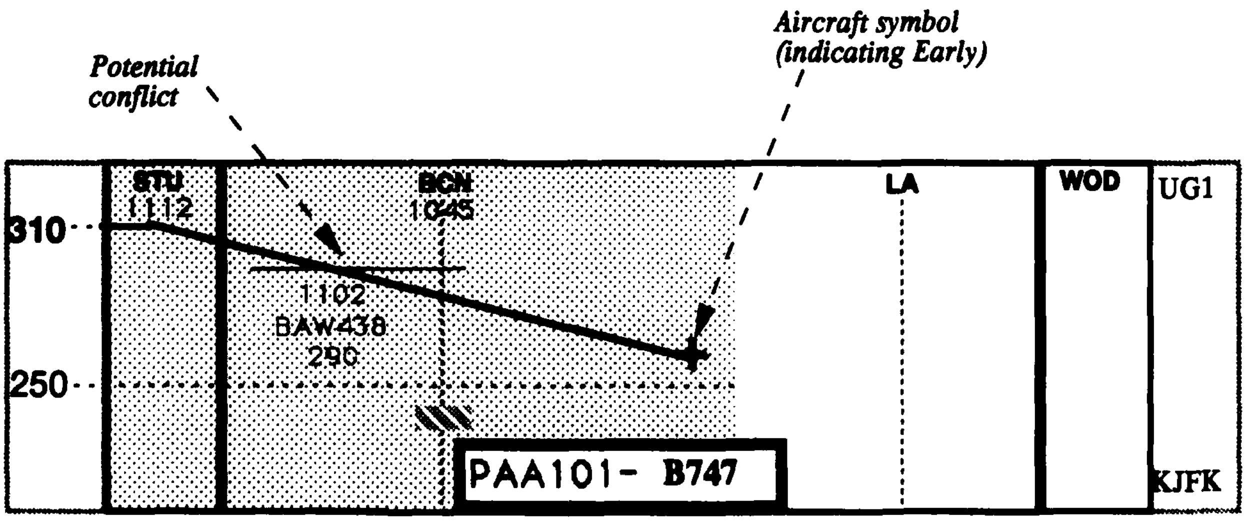


PROFILE DATA STRIP - EASTBOUND

Note: These strips are not necessarily drawn to scale



PROFILE DATA STRIP - WESTBOUND

FIGURE 2

REPORT DOCUMENTATION PAGE

DRIC Reference Number (if known) ....

Overall security classification of sheet ....UNCLASSIFIED...

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Originators Reference/Report No.	Month	Year
MEMO 4460	FEBRUARY	1991

Originators Name and Location

RSRE, St Andrews Road
Malvern, Worcs WR14 3PS

Monitoring Agency Name and Location

Title

THE PROFILE DATA STRIP: A NEW APPROACH TO THE PRESENTATION OF FLIGHT PROGRESS DATA

Report Security Classification	Title Classification (U, R, C or S)
UNCLASSIFIED	U

Foreign Language Title (in the case of translations)

Conference Details

Agency Reference	Contract Number and Period

Project Number	Other References

Authors	Pagination and Ref
COOK, J O; BASELEY, D A	10

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Abstract Classification (U,R,C or S)
U

Descriptors

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UNLIMITED

580/48

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